Research Results

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My research interests lie in gravitational physics. In particular, I focus on black hole physics and cosmology in higher dimensional spacetime. One the most promising candidate for the fundamental theory, which attempts to unify gravity with the other forces into a consistent quantum theory, is the superstring theory. It is naturally and consistently formulated in higher dimensional spacetime rather than four dimensions.

Hawking temperature for non-stationary black holes:

The fact that black holes possess thermodynamic properties has been intriguing in gravitational and quantum theories, and is still attracting interest. Nowadays it is well-known that black holes will emit thermal radiation with Hawking temperature proportional to the surface gravity of the event horizon. It is interesting to study if such thermal properties persist when time dependence is turned on. However, the original derivation of the Hawking radiation was performed on a static or stationary background (precisely speaking, as an approximation at late time), and it is not obvious how to accommodate dynamical spacetimes into the scheme.

I and my collaborator have considered the conventional derivation of the Hawking radiation based on Bogoliubov transformations for non-stationary background. For a spacetime whose evolution is sufficiently slow, we have showed that the temperature is determined by the surface gravity of the past horizon.

Non-equilibrium condensation process in a holographic superconductor:

It has been believed that the AdS/CFT correspondence plays a central role in the study of the strongly coupled region of quantum field theory because it is simply described by classical gravity theory on AdS spacetimes. Recently, the duality between the superconductor and gravity theory has been proposed as a new application of the AdS/CFT correspondence, in which the simplest gravity theory is given by Einstein-Maxwell-charged scalar theory with negative cosmological constant.

I and my collaborators have studied phase transition of holographic superconductor by solving time-evolutions of Einstein–Maxwell–complex scalar system numerically. We have showed that initial perturbations for Reissner-Nordström-AdS with low temperature grow exponentially and eventually the spacetimes settle into the black holes with scalar hair. Then, we have clarified how it evolve in non-equilibrium process during the phase transition.

Stability of flux compactifications:

Flux compactifications are simple models with a stabilization mechanism that the extra dimensions are dynamically compactified and stabilized by a flux of anti-symmetric tensor field or form field. I and my collaborators have studied stability of flux compactifications with 4-dimensional de Sitter space from both dynamical and thermodynamic perspectives. For the 6-dimensional flux compactification braneworld and the Freund–Rubin compactification, we have examined the dynamical stability by analyzing perturbative stability of the system and showed that the branch of dynamically stable solutions is thermodynamically favored with respect to the de Sitter entropy defined by the total area of the cosmological horizon. This fact suggests that the close connection between dynamical stability and thermodynamic stability exists not only for black objects but also for flux compactifications with de Sitter space.